# CHAPTER 9

# INSTALLATION OF RAM MODULES

## INTRODUCTION

The basic purpose of memory is to remember the information for a period of time. Humans have their memory in their brains, which is a part of the human body. Computers also have memory as a part of the computer system. Computer memory is the storage space in the computer, to store data and instructions. The memory is divided into a large number of small parts called cells. Computer has internal as well as external storage. The internal storage is known as primary or main memory while external storage is known as secondary storage. There are different types of memory and each one plays an important role in the running the computer system. In this Chapter, we will mainly understand the primary memory, RAM and its types. Installation of RAM modules in the computer is also demonstrated in this Chapter.

## IMPORTANCE OF MEMORY IN COMPUTERS

Memory is one of the most essential components of a computer. The CPU is constantly using memory right from the startup to shut down of the computer.

When you turn on the computer, the computer loads data from read-only memory (ROM) and performs a power-on self-test (POST) to make sure that all the major components are functioning properly. Memory controller checks all the memory addresses with a quick read/write operation to ensure that there are no errors in the memory chips. Read/write means that data is written to a bit and then read from that bit.

The computer loads the Basic Input/Output System (BIOS) from ROM. The BIOS provides the most basic information about storage devices, boot sequence, security, plug and play capability, and a few other items.

The computer loads the operating system (OS) from the hard drive into the system's RAM. Generally, the critical parts of the operating system are maintained in the RAM as long as the computer is on. This allows the CPU immediate access to the operating system, which enhances the performance and functionality of the overall system.

When you open an application, it is loaded into RAM. After loading an application, any files that are open for use in that application, are loaded into RAM. When you save a file and close the application, the file is written to the specified storage device and then the file and applications are removed from the RAM.

In the above process, RAM is used as a temporary storage so that the CPU can access that information more easily. The CPU requests the data from RAM, processes it, and sends the output back to RAM in a continuous cycle. In computers, this shuffling of data between the CPU and RAM happens millions of times per second. The outputs are saved permanently on the storage device. If the output is not saved to a permanent storage device, the data is lost.

## Classification of memory

Computer memory is classified as either internal or external memory:

### Internal memory

It is also called as main or primary memory. It refers to memory that stores small amount of data, that can be accessed quickly while the computer is running.

### External memory

It is also called secondary memory. It refers to a storage device that can retain or store data persistently. There are internal or removable storage devices. Examples include hard disk or solid state drives, USB flash drives, and compact discs (CD).

There are basically two kinds of internal memory—ROM and RAM.

#### *ROM*

It is read-only memory. It is non-volatile, which means it can retain data even without power. It is used mainly to start or boot up a computer. The data in ROM can only be read by CPU but it cannot be modified. The CPU cannot directly access the ROM memory, the data has to be first transferred to the RAM and then the CPU can access that data from the RAM.

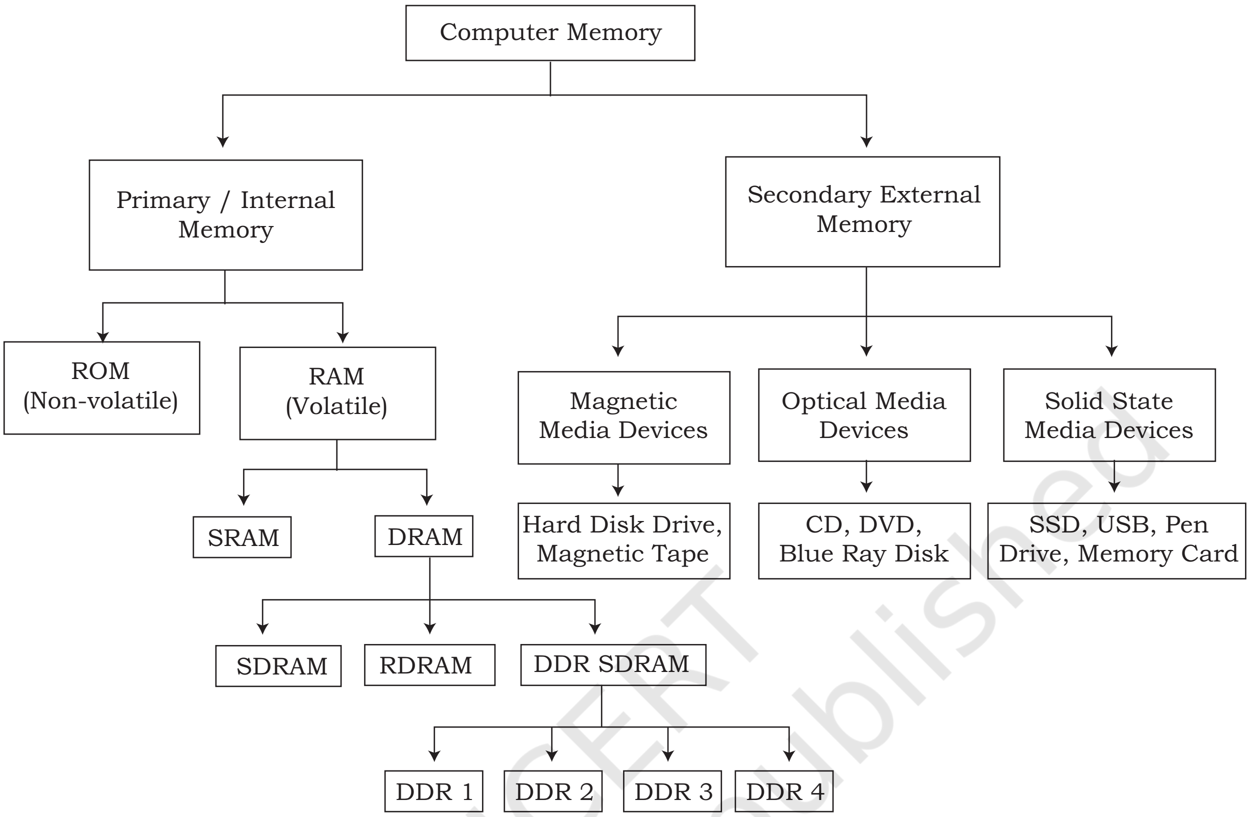


*Fig. 9.1: Different types of memory*

ROM stores the instructions requires during a process of booting up of the computer (bootstrapping). The content in ROM cannot be modified and the data inside the ROM is retained even after the CPU is switched off.

The capacity of ROM is comparatively smaller than that of RAM, it is slower and cheaper than RAM. There are many types of ROM as given below:

**PROM (Programmable read-only memory):** It can be programmed by an user. Once programmed, the data and instructions in it cannot be changed.

**EPROM (Erasable Programmable read-only memory):** It can be reprogrammed. To reprogram it, one has to erase all the previous data. Data can be erased by exposing it to ultraviolet light

**EEPROM (Electrically Erasable Programmable read only memory):** Only portions of this chip can be erased by applying an electric field.

### *RAM*

It is random access memory, it means the CPU can directly access any address location of RAM memory. It is quickly accessible memory of the computer and its speed is measured in nanoseconds (billionths of a second).

It is a read-write memory of the computer. The processor can read the instructions from RAM and write the result to the RAM.

It is fast and volatile which means it stores the data temporarily till the power is switched ON while the CPU is executing other tasks. It is therefore important to save data to the storage device before the system is turned off. Modern computers have RAM ranging from 2 GB to 16 GB.

There are two main types of RAM—Dynamic RAM (DRAM) and Static RAM (SRAM).

#### *Dynamic random access memory (DRAM)*

It is widely used as a computer's main memory. Each DRAM memory cell is made up of a transistor and a capacitor within an integrated circuit. It uses one capacitor and one transistor to store each bit (binary digit) of information. The capacitor needs to be regularly refreshed to hold the charge. This configuration uses very few components per bit, keeping the cost low but the constant refresh reduces the speed.

#### *Static random access memory (SRAM)*

It does not need to be periodically refreshed. It uses switching circuitry instead of capacitors and can hold the charge without constant refresh. It requires more components to store data per bit, so it is more expensive. It is faster, has lower density, and uses less power than DRAM. Due to its speed, SRAM is commonly used for CPU cache but not as the primary RAM due to its higher cost. It is widely used in portable gadgets such as cell phones, where minimum power consumption is important.

Common types of DRAM

1. Synchronised dynamic random access memory (SDRAM): It was the first type of memory to run in sync with the processor bus, the connection between the processor and other components on the motherboard. It is synchronised with a clock for faster speed. Typical SDRAM transfers data at speeds up to 133 Mhz. Almost all primary DRAM used in computers today is SDRAM. Most 168 pin DIMM modules use SDRAM memory. To determine whether a DIMM module contains SDRAM memory, check its speed markings. SDRAM memory is rated by bus speed. PC66 equals 66 MHz bus speed, PC100 equals 100 MHz bus speed, and PC133 equals 133 MHz bus speed.
2. Rambus dynamic random access memory (RDRAM): It takes its name after the company that made it, Rambus. It was popular in the early 2000s and was mainly used for video game devices and graphics cards, with transfer speeds up to 1 Ghz.
3. Double data rated synchronous dynamic random access memory (DDR SDRAM): It is a type of synchronous memory that nearly doubles the bandwidth of a single data rate. DDR SDRAM performs two transfers per clock cycle. 184 pin DIMM memory modules use DDR SDRAM chips. It is rated in Mhz and by throughput (MBps). The speeds for DDR SDRAM are PC1600 (200MHz/1600Mbps), PC2100 (266MHz/2100Mbps) PC2700 (333MHz/2700 Mbps), and PC3200 (400MHz/ 3200Mbps).
   (a) DDR1 SDRAM: It has been succeeded by DDR2, DDR3, and most recently, DDR4 SDRAM. Although operating on the same principles, the modules are not compatible with the earlier modules of RAM. Each generation delivers higher transfer rates and faster performance. The latest DDR4 modules feature fast transfer rates at 2133/2400/2666 and even 3200 MT/s.

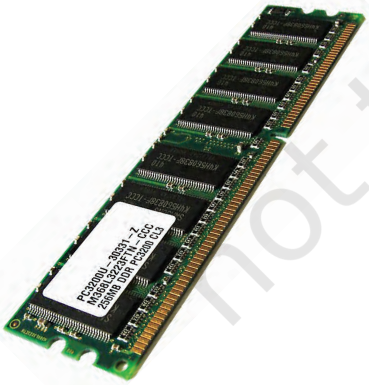


*Fig. 9.2: DDR1 SDRAM*

(b) DDR2 SDRAM: It runs its external data bus at twice the speed of DDR SDRAM and features a four-bit pre-fetch buffer, enabling faster performance. DDR2 SDRAM memory has greater latency than DDR SDRAM memory. Latency is a measure of how long it takes to receive information from memory— the higher the number, the greater the latency. 240 pin memory modules use DDR2 SDRAM. Common speeds for DDR2 SDRAM modules includes PC2-3200 (DDR2-400; 3200Mbps throughput); PC2-5300 (DDR2-667); PC2-6400 (DDR2-800); and PC2-8500 (DDR2-1066).

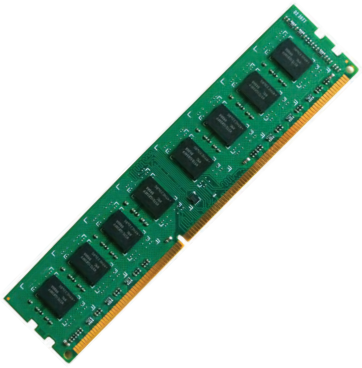


*Fig. 9.3: DDR2 SDRAM*

(c) DDR3 SDRAM: It runs on lower voltages, has twice the internal banks and most versions run at faster speeds than DDR2. It also has an 8 bit prefetch bus with greater latency than DDR2. Although DDR3 modules also use 240 pins, their layout and keying are different than DDR2, and they cannot be interchanged. The common speeds for DDR3 SDRAM modules include PC3-8500 (DDR3-1066; 8500MBps throughput); PC3-12800 (DDR3-1600); and PC3-17000 (DDR3-2133).

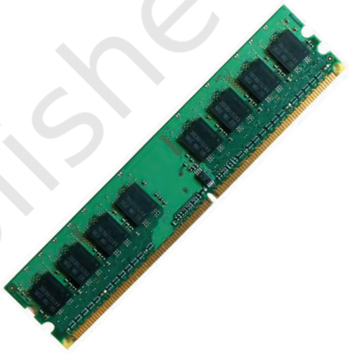


*Fig. 9.4: DDR3 SDRAM*

(d) DDR4 SDRAM: It was introduced alongside Intel's X99 chipset for Core i-series processors in August 2014 and is the fourth generation of DDR memory. It runs on lower voltage (1.2V) and supports density up to 16 Gb per chip (twice the density of DDR3), twice the memory banks and uses bank groups to speed up access to memory, but uses the same eight-bit prefetch as DDR3. Data rates range from 1600 Mbps to 3200 Mbps, compared to 800 Mbps to 2133 Mbps for DDR3.

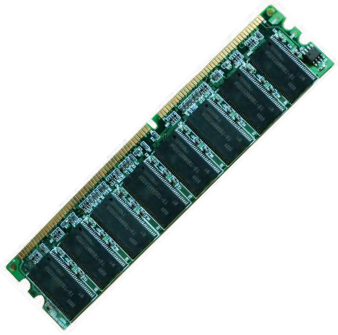
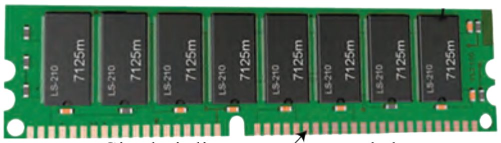


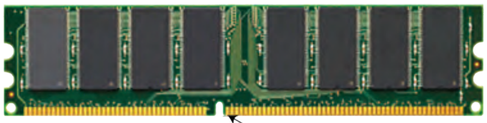
*Fig. 9.5: DDR4 SDRAM*

Types of DRAM packages

(i) Single in-line memory module (SIMM): These modules were widely used from the late 1980s to 1990s, and are now obsolete. They typically had



Single inline memory module



Dual inline memory module

*Fig. 9.6: SIMM and DIMM Modules*

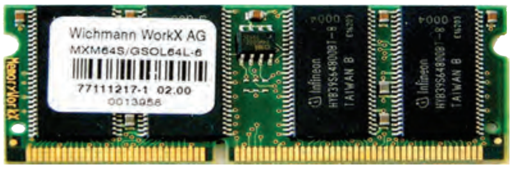


*Fig. 9.7: SODIMM*

32 bit data bus and were available in two physical types—30 and 72 pin.

(ii) Dual in-line memory module (DIMM): Current memory modules come in DIMMs. ‘Dual in-line’ refers to pins on both sides of the modules. These moduless originally had a 168 pin connector supporting a 64 bit data bus, which is twice the data width of SIMMs. The wider bus means that more data can pass through a DIMM, translating to faster overall performance. Latest DIMMs are based on fourth generation double data rate (DDR4). SDRAM have 288 pin connectors for increased data throughput.

(iii) DIMM and SODIMM: RAM comes on cards plugged into the slots in the motherboard. They are smaller than expansion cards and technicians commonly call them memory cards, sticks. The two most common types of memory sticks are DIMM and SODIMM.

Dual in-line memory module (DIMM) is the circuit board that holds the memory chips. They are long and are used in desktop computers. DIMM have 168, 184, or 240 pins all supporting 64 bit data transfer.

Small outline dual in-line memory module (SODIMM) chips are smaller and are used in smaller devices such as laptop computers and printers. SODIMM have 72, 100, 144, or 200 pins. The 100 pin package supports 32 bit data transfer, while the 144 and 200 pin packages support 64 bit data transfer.

*RAM configurations*

Almost all systems can be used with a variety of memory sizes. However, systems that are designed to access two or more identical modules as a single logical unit (multi-channel) provide faster performance than systems that access each module as a unit.

Single and multichannel memory modes: Many motherboards and CPUs support single-channel, dual-channel, and triple-channel memory architectures. Each single channel represents a separate 64-bit line of communication that can be accessed independently. With dual channel, the system can access 128 bits at a time; triple channel gives access to 192 bits at a time.

Using dual and triple channels provides an additional performance enhancement to DDR, DDR2, and DDR3 in addition to double pumping and other enhancements provided by the DDR versions. If you use a dual-channel motherboard with DDR3, it doubles the throughput of DDR3, providing 16 times more data throughput than SDRAM.

If you are upgrading a computer's memory, it is important to understand these channels. You can purchase DIMMs in matched pairs. Where you install each DIMM, determines how many channels your system will use and can affect the performance of RAM.

(i) Single-channel (asymmetric) mode: Originally, all systems that used SDRAM were single-channel systems. Each 64-bit DIMM or SODIMM module was addressed individually. This mode provides single-channel bandwidth operations and is used when only one DIMM is installed or when the memory capacities of more than one DIMM are unequal. When using different speed DIMMs between channels, the slowest memory timing is also used.

(ii) Dual-channel mode: The DDR memory technology supports dual-channel operation. When two identical (same size, speed, and latency) modules are installed in the proper sockets, the memory controller accesses them in interleaved mode for faster access.

Dual-channel motherboards are very common. This mode offers higher memory throughput and is enabled when the memory capacities of both DIMM channels are equal. When using different speed DIMMs, the slowest memory timing is used. If you look at a dual-channel motherboard, you see that it has four memory slots, two slots of one colour and two slots of another colour. Figure 9.8 shows a diagram of four memory slots labelled for a motherboard using an Intel based CPU. Slots 1 and 3 are of one color and slots 2 and 4 are of another color.

(i) Slots: Each slot can accept one DIMM.

(ii) Banks: A bank is composed of two slots. Bank 0 includes slots 1 and 3 and these two slots are normally blue. Bank 1 includes slots 2 and 4 and these slots are normally black. This is standard for Intel CPU based another boards.

(iii) Channels: Each channel represents a separate 64-bit communication path. Slots 1 and 2 make up one channel, and slots 3 and 4 make up the second channel.

You can install a single DIMM in slot 2 as shown in Figure 9.8 and the system will have a single-channel RAM. You can purchase DIMMs in matched pairs and it is important to know in which slots to install them. For the best performance, you should install matching DIMMs in the same bank. Install the matched pair of DIMMs in slots 2 and 4 (Bank 1) as shown in Figure 9.9 leaving slots 1 and 3. The system will take advantage of the dual-channel architecture by using two separate 64-bit channels. To achieve dual-channel mode, the following conditions must be met:

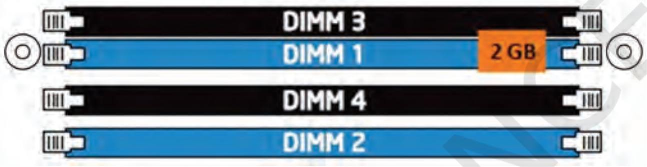


*Fig. 9.8: Single-channel with one DIMM*

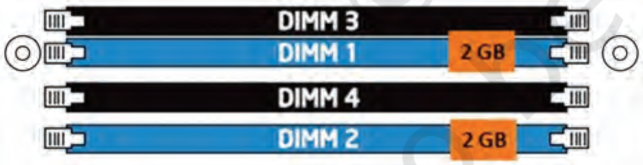


*Fig. 9.9: Dual-channel with two DIMMs*

- same memory size: 1 GB, 2 GB, 4 GB
- matched DIMM configuration in each channel.
- matched in symmetrical memory slots.

The motherboard uses the same colour for each bank. For Intel-based motherboards, Bank 0 includes slots 1 and 3 with the same colour (black). Bank 1 includes slots 2 and 4 with different colour (blue).

In AMD motherboards, slots 1 and 2 make up Bank 0 and slots 3 and 4 make up Bank 1. Channel 1 includes slots 1 and 3 and channel 2 includes slots 2 and 4. AMD motherboards also use one color for Bank 0 (slot 1 and 2), and another colour for Bank 1 (slot 3 and 4).

(iii) Triple-channel mode: On some motherboards, there are six DIMM slots instead of four. This indicates the system supports triple-channel memory usage. Triple-channel interleaving reduces overall memory latency by accessing the DIMM memory sequentially. Data is spread through the memory modules in an alternating pattern. Triple-channel mode is enabled when identical matched memory modules are installed in each of the three blue memory slots.

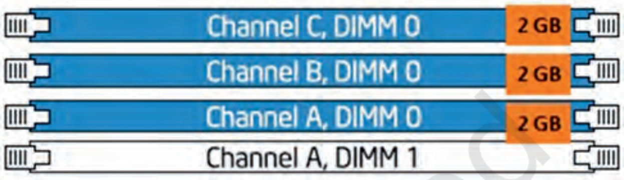


*Fig. 9.10: Triple-channel mode*

(iv) Quad-channel mode: This mode is enabled when four (or a multiple of four) DIMMs are identical in capacity and speed, and are put in quad-channel slots. When two memory modules are installed, the system operates in dual-channel mode. When three memory modules are installed, the system operates in triple-channel mode.

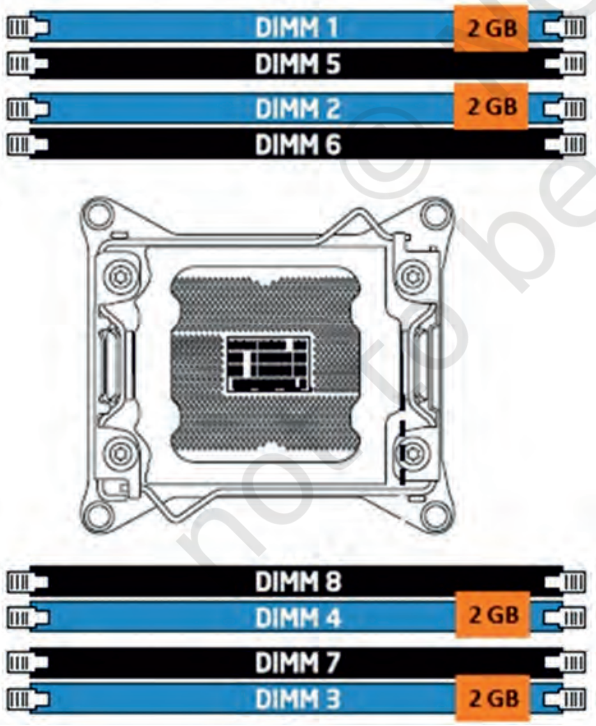


*Fig. 9.11: Quad-channel with four DIMMs*

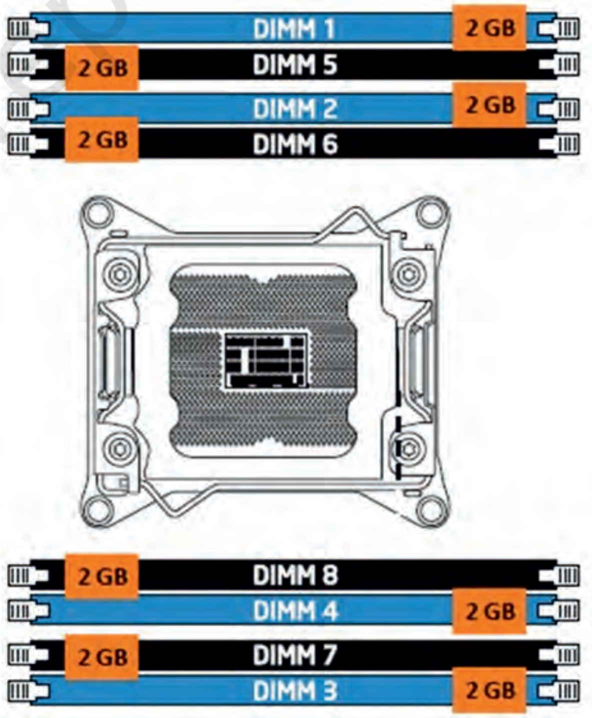


*Fig. 9.12: Quad-channel with eight DIMMs*

*RAM speed*

RAM is accessed by the CPU via the front-side bus (FSB) and the memory bus. The high quality RAM is likely to operate with close to 100% reliability, significantly above the bus speed for which it is rated. The following table shows some comparisons of peak memory performance.

**Table 9.1 Performance of various memory modules**

| Type of RAM | PC rating | RAM speed in MHz | Peak throughput in MB/sec |
|---|---|---|---|
| SDRAM | PC100 | 100 | 800 |
| SDRAM | PC133 | 133 | 1100 |
| RIMM | PC800 | 400 | 1600 |
| RIMM | PC1066 | 533 | 2100 |
| DDR | PC1600 | 200 | 1600 |
| DDR | PC2100 | 266 | 2100 |
| DDR | PC2700 | 366 | 2700 |
| DDR | PC3200 | 400 | 3200 |
| Dual Channel RIMM | PC800 | 400 | 3200 |
| Dual Channel RIMM | PC1066 | 533 | 4200 |
| Dual Channel DDR2 | PC2-3200 | 400 | 6400 |
| Dual Channel DDR2 | PC2-4200 | 533 | 8400 |
| Dual Channel DDR2 | PC2-5300 | 667 | 10600 |
| Dual Channel DDR2 | PC2-6400 | 800 | 12800 |

## Practical Activity

**Installation of RAM**

- First, open the computer cabinet. To open the case, remove the screws of the left side cover and slide the side cover. Pull the latch to release the side panel. Then lift the side cover out from the chassis.
- To install the RAM, first ensure its compatibility with the motherboard. If DDR3 is mentioned on the motherboard, then DDR3 RAM may be fixed in the memory slot.

- Press down the side locks of the memory slot. Align the notches on the RAM module to the keys in the slot and press down on the both ends of RAM module until the side lock gets locked.

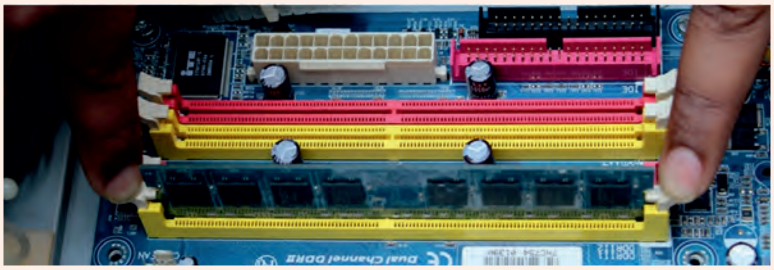


*Fig. 1: Press down the memory in slot*

- Make sure that the side tabs have locked the RAM module.
- Repeat the above steps to install additional RAM modules.

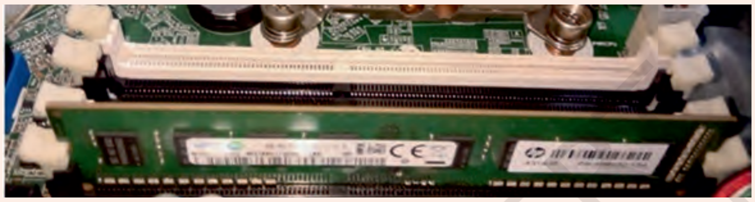


*Fig. 2: Lock the RAM module*

## Check Your Progress

### A. Multiple choice questions

1. Which of the following loses its contents when you shut down the computer?
   (a) Hard disk drive (b) USB flash drive
   (c) RAM (d) ROM
2. Component most likely used for computer static RAM technology is ___________.
   (a) primary memory (b) secondary storage
   (c) cache memory (d) CPU registers
3. Which of the following statements is correct about RAM?
   (a) It retains data when PC is turned off.
   (b) It is a type of read and write memory.
   (c) It contains start up instructions.
   (d) It is peripheral.
4. RAM is volatile memory because___________.
   (a) it can be used for both read and write
   (b) any location can be accessed directly into it
   (c) continuous power supply is required for it to retain data
   (d) it does not require continuous power supply

NOTES

5. Which of the following is the second largest measurement of RAM?
   (a) Terabyte
   (b) Megabyte
   (c) Byte
   (d) Gigabyte
6. __________ consists of volatile chips that temporarily store data or instructions.
   (a) CPU
   (b) ROM
   (c) RMA
   (d) RAM
7. What is the meaning of RAM, and what is its primary role?
   (a) Readily available memory; it is the first level of memory used by the computer in all of its operations.
   (b) Random access memory; it is memory that can be reached by any sub-system within a computer, and at any time.
   (c) Random access memory; it is the memory used for short-term temporary data storage within the computer.
   (d) Resettable automatic memory; it is memory that can be used and then automatically reset, or cleared, after being read from or written to.
8. Which of the following is volatile storage?
   (a) ROM
   (b) RAM
   (c) Secondary storage
   (d) Hard disk
9. Which is the fastest data storage in a computer?
   (a) Registers
   (b) RAM
   (c) HDD
   (d) ROM

### B. Fill in the blanks

1. RAM is used as a temporary storage area so that the _________ can access that information more easily.
2. The data in ROM can only be read by ___________.
3. Dynamic random access memory (DRAM) is widely used as a computer's _____________.
4. Static random access memory (SRAM) does not need to be periodically____________.
5. DDR3 SDRAM runs at lower ____________.
6. To install the RAM first ensure its compatibility with ______________.
7. In dual channel, the system can access _________ bits at a time.
8. The DDR memory technology supports _________ channel operation.
9. Each channel represents a separate _________ bit communication path.
10. The RAM is accessed by the _______________.

## C. State whether the statements are True or False

1. Static memory will maintain storage even if power is removed.
2. RAM is non-volatile.
3. RAM has a slow access time relative to other storage devices.
4. RAM can be static or dynamic.
5. RAM holds the BIOS.
6. RAM is part of the hard disk.
7. ROM is volatile.
8. RAM stores programs/data used by the CPU.
9. ROM contains the operating system.
10. RAM stands for readily accessible memory.

## D. Short answer questions

1. Why is memory important in a computer?
2. What is RAM?
3. Why are different types of RAM used?
4. What are the different types of RAM?
5. What are the common types of DRAM?
6. Describe different types of DRAM packages.
7. Describe DIMM and SODIMM.
8. What are the differences between single and multichannel memory modes?